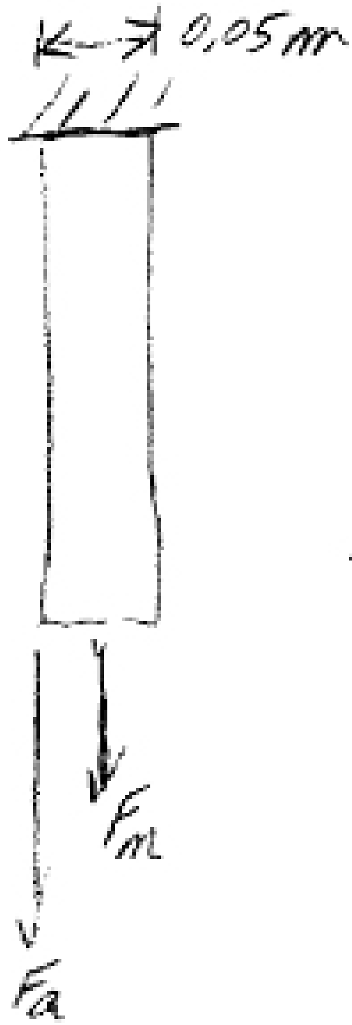

$\sigma_{yp} = 280$ MPa $\sigma_u = 350$ MPa

$P_{mean} = 100$ kN

FATIGUE STRENGTH = 210 MPa @ 10^6 cyc.

DETERMINE THE AMPLITUDE OF THE CYCLING FORCE FOR NO FATIGUE FAILURE AT 10^6 CYCLES

$$M_a = eF_a = 0.025\,F_a$$

$$\sigma_a = \frac{M_a c}{I} = \frac{(0.025)F_a\,(0.025)}{(0.05)^4/12} = 1200 F_a$$

$$\sigma_m = \frac{F_m}{A} = \frac{100{,}000}{(0.05)^2} = 40\text{ MPa}$$

APPLY SODERBERG CRITERIA

$$\frac{\sigma_a}{\sigma_{cr}} + \frac{\sigma_m}{\sigma_{yp}} = 1$$

$$\frac{1200\,F_a}{210\times10^6} + \frac{40\times\cancel{10^6}}{280\times\cancel{10^6}} = 1$$

$$F_a = \left(1-\frac{40}{280}\right)\left(\frac{210\times10^6}{1200}\right) = 150000\text{ N}$$
$$= 150\text{ kN}$$

APPLY MODIFIED GOODMAN CRITERIA

$$\frac{\sigma_a}{\sigma_{cr}} + \frac{\sigma_m}{\sigma_u} = 1$$

$$\frac{1200 F_a}{210 \times 10^6} + \frac{40 \times 10^6}{350 \times 10^6} = 1$$

$$F_a = \left(1 - \frac{40}{350}\right)\left(\frac{210 \times 10^6}{1200}\right) = 155000\ N$$
$$= 155\ kN$$

APPLY GERBER CRITERIA

$$\frac{\sigma_a}{\sigma_{cr}} + \left(\frac{\sigma_m}{\sigma_u}\right)^2 = 1$$

$$\frac{1200 F_a}{210 \times 10^6} + \left(\frac{40 \times 10^6}{350 \times 10^6}\right)^2 = 1$$

$$F_a = \left(1 - \left(\frac{40}{350}\right)^2\right)\left(\frac{210 \times 10^6}{1200}\right) = 172\,714\ N$$
$$= 173\ kN$$

APPLY SAE CRITERIA

$$\frac{\sigma_a}{\sigma_{cr}} + \frac{\sigma_m}{\sigma_f} = 1$$

$$\frac{1200 F_a}{120 \times 10^6} + \frac{40 \times 10^6}{350 \times 10^6} = 1$$ (SAME AS MODIFIED GOODMAN)

MODIFIED GOODMAN SAE	SODERBERG	GERBER
155 kN	150 kN	173 kN

COMBINED LOADING

USE MODIFIED STATIC FAILURE CRITERIA

MAXIMUM DISTORTIONAL ENERGY THEORY

$$(\sigma_{xa}-\sigma_{ya})^2+(\sigma_{ya}-\sigma_{za})^2+(\sigma_{za}-\sigma_{xa})^2+6(\tau_{xya}^2+\tau_{xza}^2+\tau_{yza}^2) = 2\sigma_{ea}^2$$

$$(\sigma_{xm}-\sigma_{ym})^2+(\sigma_{ym}-\sigma_{zm})^2+(\sigma_{zm}-\sigma_{xm})^2+6(\tau_{xym}^2+\tau_{xzm}^2+\tau_{yzm}^2) = 2\sigma_{em}^2$$

$$(\sigma_{1a}-\sigma_{2a})^2+(\sigma_{2a}-\sigma_{3a})^2+(\sigma_{3a}-\sigma_{1a})^2 = 2\sigma_{ea}^2$$

$$(\sigma_{1m}-\sigma_{2m})^2+(\sigma_{2m}-\sigma_{3m})^2+(\sigma_{3m}-\sigma_{1m})^2 = 2\sigma_{em}^2$$

MAX PRINCIPAL STESS THEORY

$$\frac{\sigma_{1a}}{\sigma_{1u}}+\frac{\sigma_{1m}}{\sigma_{1u}} = \pm 1 \quad \text{or} \quad \frac{\sigma_{1a}}{\sigma_{1yp}}+\frac{\sigma_{1m}}{\sigma_{1yp}} = \pm 1$$

$$\frac{\sigma_{2a}}{\sigma_{2u}}+\frac{\sigma_{2m}}{\sigma_{2m}} = \pm 1 \quad \text{or} \quad \frac{\sigma_{2a}}{\sigma_{2yp}}+\frac{\sigma_{2m}}{\sigma_{2yp}} = \pm 1$$

MAXIMUM SHEARING STRESS

(σ_1 & σ_2 OPPOSITE SIGN)

$$\frac{\sigma_{1a}+\sigma_{1m}}{\sigma_{yp}} - \frac{\sigma_{2a}+\sigma_{2m}}{\sigma_{yp}} = \pm 1$$

SAME SIGN

$$|(\sigma_{1a}+\sigma_{1m})-(\sigma_{3a}+\sigma_{3m})| = \sigma_{yp}$$